

Nuclear Reactors, Bombs

Intro to Standard Model

p1117

Q41

$$m \text{ U232} = 232.03713 \text{ u}$$

$$m \text{ Th 228} = 228.02873 \text{ u}$$

$$m \text{ He 4} = 4.002603 \text{ u}$$

mass defect = mass of product-mass of reactants
= $(228.02873 + 4.002603) - 232.03713 = -0.005797 \text{ u}$

(should you include the mass of electrons?)

$$= (228.02873 + 4.001506) - 232.03713 = -0.006894$$

$E = mc^2$ but we know that $1 \text{ u} = 931.5 \text{ MeV}$ (derived last class)

$$0.005797 \times 931.5 = 5.399906 \text{ MeV}$$

$$0.006894 \times 931.5 = 6.421761 \text{ MeV}$$

Keeners try this question: how fast is each nucleus moving?

$$E_k = \frac{1}{2}mv^2$$

$$p_{\text{Th}} = p_{\text{He}}$$

$$m_{\text{Th}}v_{\text{Th}} = m_{\text{He}}v_{\text{He}}$$

$$\frac{1}{2}m_{\text{Th}}(v_{\text{Th}})^2 + \frac{1}{2}m_{\text{He}}(v_{\text{He}})^2 = 5.399906 \text{ MeV}$$

solve the quadratic

cool, eh?

Q75

mass of products-mass of reactants

$$(4.001506 + (2 \times 0.000548580)) - (4 \times 1.007276) = -0.02650084 \text{ u}$$

$$E = M \times 931.5 \text{ MeV/u}$$

$$= 0.02650084 \times 931.5 = 24.68553246 \text{ MeV}$$

$$= 24.69 \text{ MeV}$$

When should you use the mass of He4 4.002603u and when should you use alpha (no electrons) 4.001506u ?

In question 41, Thorium will be Th^{-2} so the electrons are still there, just not on the alpha particle.

In Question 75, the protons have no electrons.

Q51

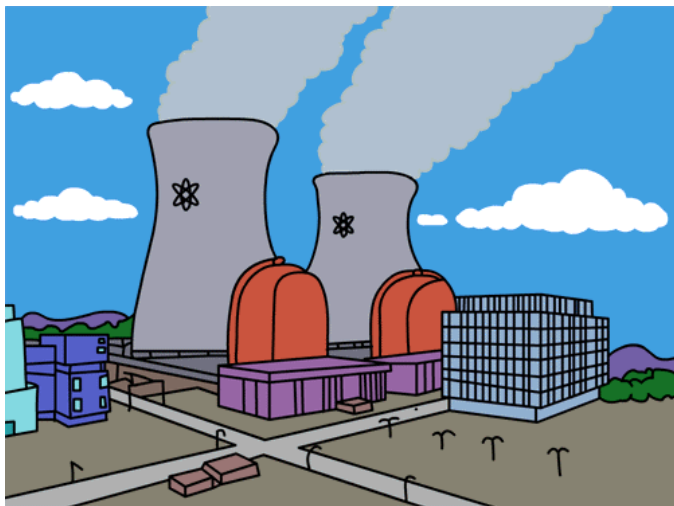


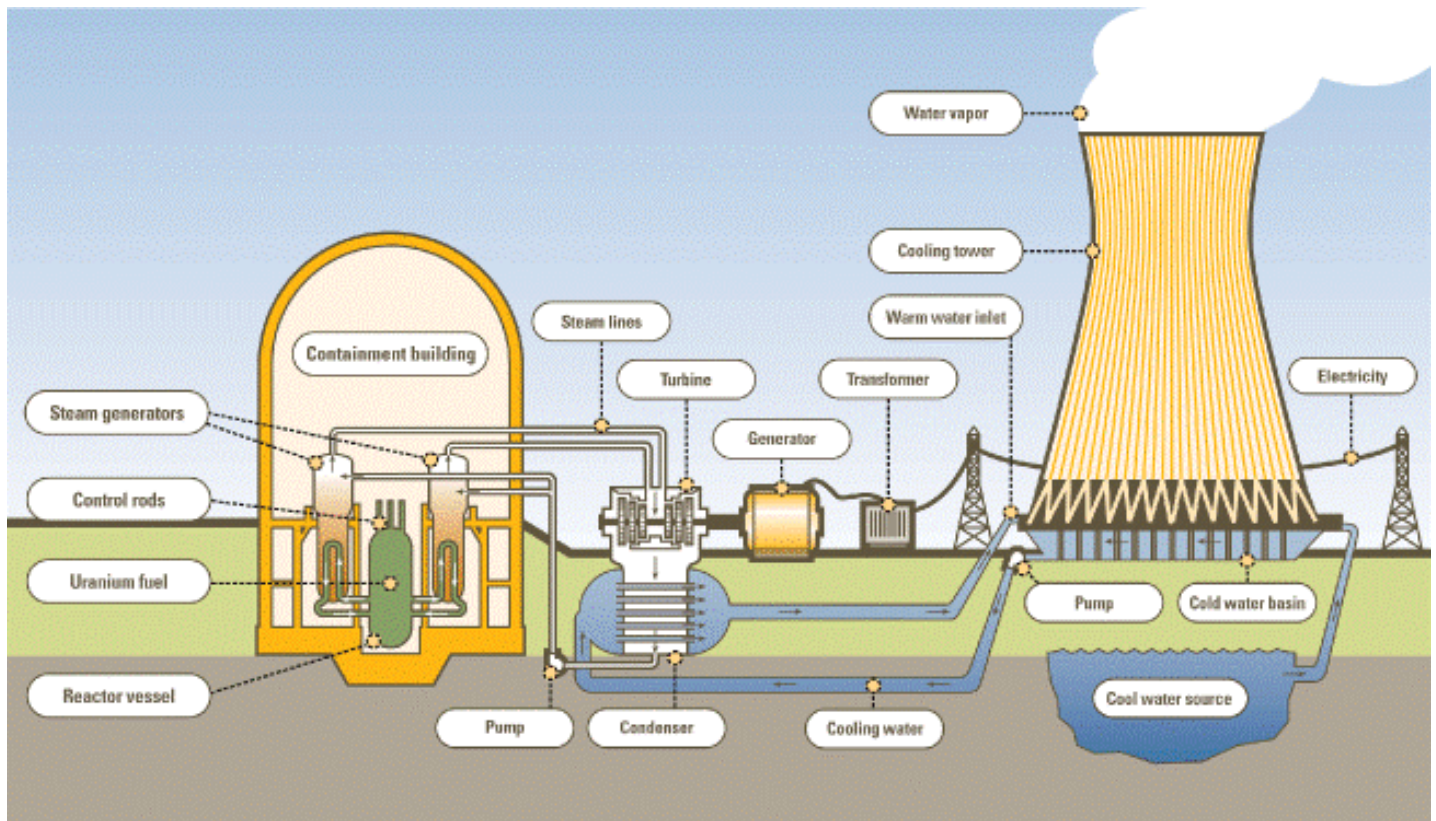
mass of products-mass of reactants

$$(16.9991312 + 1.007276) - (4.002603 + 14.003074005) = 0.000730195 \text{ u}$$

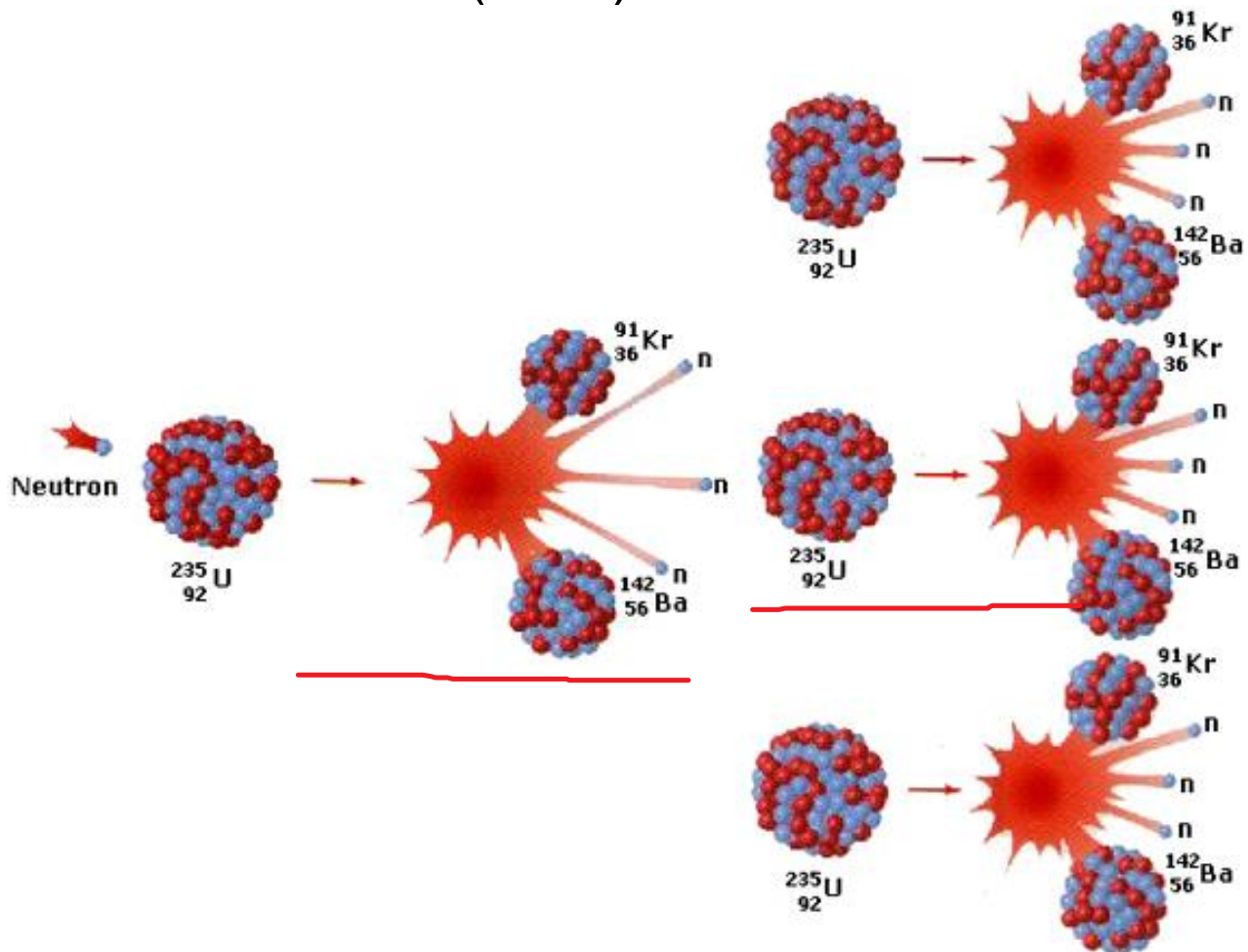
$$E = 0.000730195 \times 931.5 = 0.680176643$$

0.68 MeV that has to go in





Uranium 235 undergoes fission when struck with a thermal neutron (slow)



The neutrons produced initiate more reactions.

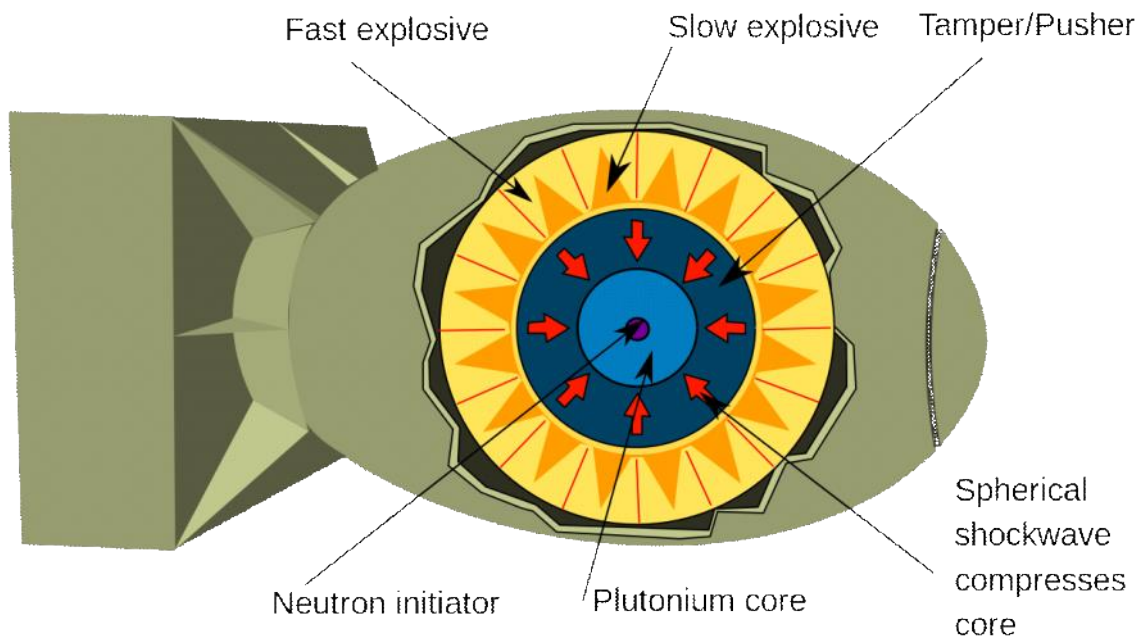
If the mass of fissionable material is above a certain amount, called the critical mass, a sustained chain reaction can occur (reactions start more reactions.)

Moderator - slows the neutrons to increase the likelihood of reaction, speeds up the reaction.
eg. heavy water, graphite,

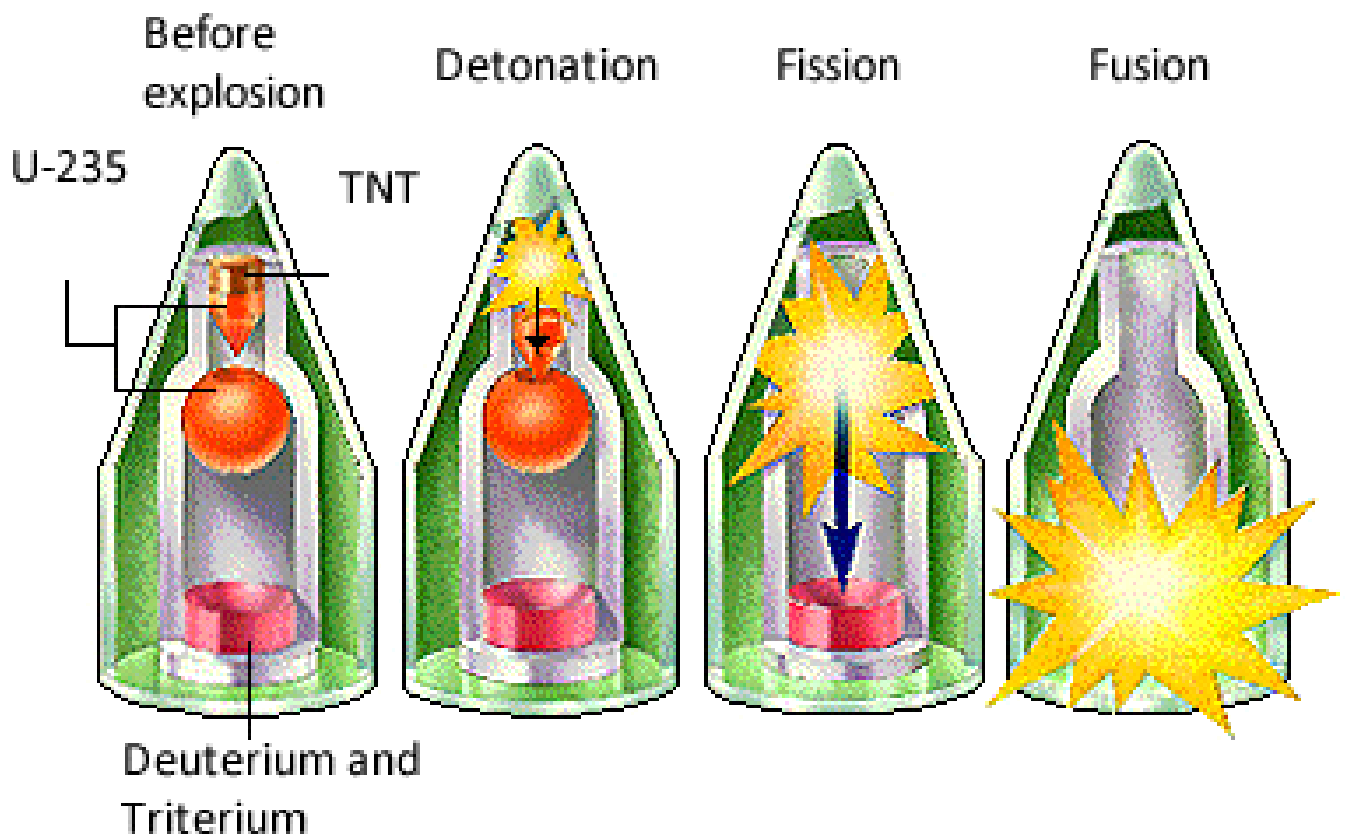
Control rods - absorb the neutrons to slow the reaction.
eg. cadmium,

Neutron source - Chadwick bombarded paraffin with alpha particles and neutrons were given off.

Plutonium 239 is made when you hit U238 with neutrons and it undergoes 2 beta decays.
Reactors that make plutonium are called breeder reactors.



Explosion of a Hydrogen Bomb



Review Ch 30 for quiz next class

pre-read Ch 31